50-156

Nuclear Reactor Laboratory

University of Wisconsin-Madison

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Tech Specs, Docket 50-156

August 6, 1999

U. S. Nuclear Regulatory Commission
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Washington, D. C. 20555

Dear Sir:

Enclosed herewith is a copy of the Annual Report for the fiscal year 1998-99 for the University of Wisconsin Nuclear Reactor Laboratory as required by our Technical Specifications.

Very truly yours,

R. J. Cashwell
Reactor Director

Enc. (Annual Report)

XC: Region III Administrator

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THE UNIVERSITY OF WISCONSIN
NUCLEAR REACTOR LABORATORY

fiscal year 1998-99 ANNUAL OPERATING REPORT

Prepared to meet reporting requirements of:

U. S. Department of Energy

SPECIAL MASTER TASK RESEARCH SUBCONTRACT NO. C87-101251

and

U. S. Nuclear Regulatory Commission

(Docket 50-156, License R-74)

Prepared by:

R. J. Cashwell and John Murphy
Department of Engineering Physics

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EXECUTIVE SUMMARY OF REACTOR UTILIZATION

Teaching: Teaching usage of the reactor during the year included:

- 24 NEEP students in laboratory courses.
- 331 instructors and students from 12 area school systems were given demonstrations in reactor operations and use.
- 58 Students and staff from 7 additional college-level educational institutions used the facilities for formal instruction or research.

Research: Neutrons from the reactor were used primarily for neutron activation and analysis.

- 318 samples were irradiated for departments at UW-Madison.
- 228 samples were irradiated for other educational institution research programs.

Industrial Use:

438 samples were irradiated for industrial organizations. Irradiations or NAA services were provided to 10 different organizations.

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A. SUMMARY OF OPERATIONS

1a. INSTRUCTIONAL USE --UW-Madison Classes and Activities

NEEP 427 was offered in the spring semester with a total enrollment of 8. Several NEEP 427 experiments use materials that are activated in the reactor. One experiment entitled "Radiation Survey" requires that students make measurements of radiation levels in and around the reactor laboratory. All of these reactor uses take place during normal isotope production runs, so no reactor time is specifically devoted to NEEP 427.

The enrollment in NEEP 428 was 6 as it was offered in the spring semester. Three experiments in NEEP 428 require exclusive use of the reactor. Each of these experiments ("Critical Experiment," "Control Element Calibration," and "Pulsing") was repeated four times during the year requiring a total of 15 hours of exclusive reactor use. Other NEEP 428 laboratory sessions use material that has been irradiated in the reactor ("Fast Neutron Flux Measurements by Threshold Foil Techniques" and "Resonance Absorption"). These two experiments were repeated 8 times during the year.

Ten students completed NEEP 234, "Principles and Practice of Nuclear Reactor Operation" during the spring semester. This course uses the reactor extensively, as each student performed at least 20 significant reactivity changes. Although an effort was made to use normal scheduled reactor runs for training the students in this course, 42.4 hours of exclusive reactor use specifically for training were required to provide this operating experience. Four of the students applied for and obtained NRC Operator Licenses.

The Reactor Laboratory continues to attract large numbers of tours, with groups from public schools, day cares, scout troops, Kollege for Kids, trades apprentice programs, teacher groups, senior citizens, and service organizations visiting for tours and nuclear power information.

1b. INSTRUCTIONAL USE -Other educational institutions
See section on US DOE Reactor Sharing Program for details.

1c. INSTRUCTIONAL USE -Utility operator training
A one-day training session on subcritical multiplication and reactivity transients was presented for one group of six licensed personnel from the Braidwood Nuclear Power Station. The sequence consisted of plotting 1/M (Inverse Count Rate Ratio) versus control element bank position for prediction of the critical rod height, and comparing the prediction from that of an eight-fold count rate increase and actual critical position. The effect of a neutron source on prediction of critical with the reactor at minimum power level for critical and at 1 watt was demonstrated. Then the point of adding heat was determined, followed by measurement of transient power level reached following step changes in reactivity. This series culminated in a prompt-critical insertion demonstrating the same reactivity feedback occurs even with very large reactivity insertions. Finally, fuel temperature and reactivity loss at steady-state powers up to full power were measured. A total of 7 hours of exclusive reactor use was devoted to this program.

2. REACTOR SHARING PROGRAM

User institutions participated in the program as detailed below.

Participating Institution	Principal Investigator	Number of Faculty Students Involved
Edgewood College Madison, WI	P. Welty	1/15
NAA demonstration/reactor tour for chemistry class.		
Milwaukee School of Engineering	D. Seeley	1/7
Reactor operation demonstration, nuclear power plant discussion.		
University of Wisconsin-Stevens Point	J. Pettit	1/15
Reactor operations demonstration, nuclear power		

plant discussion, reactor uses.

Madison Area Technical College
S. Herschberger 2/53
M. Brewer
Night session on nuclear power, tour of facility used in energy utilization class.

University of Wisconsin-Milwaukee
T. Naik 2/0
Professor Naik and a research associate from the Center for Byproduct Utilization used NAA to investigate incorporation of waste products into construction materials.

University of Florida/Union County High School
1/1
NAA of soil, water, and plant tissue for a high school science project.

Non-College Groups:

High School Teachers 8/0
Professor James Blanchard (UW-Madison emeritus Physics) instructs high school teachers in modern physics during the summer session. He brings the teachers to the lab to see first hand how a nuclear reactor works and discusses pertinent issues.

Boy Scouts of America 2/27
Reactor tour, potential nuclear power applications. Discussion of shielding and neutron activation analysis. Scouts attain a merit badge for their effort.

Opportunities Conference 1/13
Reactor tour, nuclear applications discussion, uses of UW nuclear reactor. Held for non-traditional groups in engineering.

Society of Mechanical Engineers 4/36
Reactor tour and nuclear power discussion for high school students.

Spring Harbor School 1/27

Reactor tour, discussion of nuclear power applications. Students use the tour to assist in an energy technology debate at their school.

Upward Bound Program 3/32

Reactor tour and nuclear power discussion.

ESTEAM 4/32

Reactor tour and nuclear power discussion for minority high school students. Part of a program to interest minority students in technical education.

Summer Enrichment Program 1/22

Reactor tour and nuclear power discussion for minority high school students. Summer program to interest minority students in technical education.

Abundant Life Christian School 4/48

Students toured the lab and discussed nuclear power issues.

Sun Prairie High School 1/24

Reactor tour and nuclear power discussion.

Fennimore High School 1/5

Reactor tour and nuclear power discussion.

College for Kids 3/32

Reactor tour and nuclear power discussion during the summer session.

USER SUMMARY:

Educational Institutions:	19
Students:	389
Faculty/Instructors:	41

3. SAMPLE IRRADIATIONS AND NEUTRON ACTIVATION ANALYSIS SERVICES

There were 984 individual samples irradiated during the year. Of these samples, 536 were irradiated for 15 minutes or less. Samples accumulated 230.84 irradiation space hours and 752.27 sample hours. Many samples were irradiated and then counted at the Reactor Laboratory as part of our neutron activation analysis service. In the listing below the notation (NAA) indicates that the samples were processed by our neutron activation analysis service.

Elf-Atochem (NAA)
19 samples, 13.6 sample hours
NAA of plastic samples to determine amount of Flourine and specific impurities. Industrial support.

Engineering Physics (Nuclear Reactor Laboratory tests)
40 samples, 161.75 sample hours.
Production of calibration sources for required reactor measurements, measurement of neutron fluxes in experimental facilities, development of methods for instrumental neutron activation analsis. UW support.

Exxon Chemicals (NAA)
6 samples, 3 sample hours
NAA for measurement of Chlorine level in mineral oils. Industrial support

University of Florida/Union County High School (NAA)
51 samples, 46.9 sample hours
NAA of plant and earth samples to determine of cadmium level, as well as to identify minerals absorbed by the plants from the earth samples. Performed for Jonathan Breman as a science project for his high school. Services provided while the University of Florida reactor was shut down for diagnostics and maintenance. Supported by DOE Reactor Sharing Program

Kerr-McGee Chemical Company (NAA)
39 samples, 78 sample hours
NAA for determination of mercury levels in Titanium ores. Industrial support.

McCrone Associates
267 samples, 26.7 sample hours
Irradiation of plastic slides. Industrial support, but support from US Government contract.

Medical Physics Department, UW Madison
9 samples, 9 sample hours
Irradiation of gold-plates stints for preliminary work in a program to determine whether the radioactive gold aids in preventing re-blocking of an artery after the stint is placed. Currently supported by UW sources, proposal written to NIH to continue the work.

Millennium Petrochemicals (NAA)
5 samples, 2.08 sample hours
NAA of vinegar for Iodine content. Industrial support.

University of Wisconsin-Milwaukee
Center for Byproduct Utilization (NAA)
177 samples, 167.8 sample hours
Professor Naik, one additional staff member, and two graduate students used the NAA service to measure levels of various elements in concretes prepared using various byproduct materials, such as paper mill sludge, fly ash, and bottom ash.

NEEP 234 Class
4 samples, 0.4 sample hours
Irradition in support of demonstrations in the course. Included activation of argon gas in air and water, and demonstration of Nitrogen-16 production in cooling water. UW support.

NEEP 427 (Radiation Instrumentation Class)
69 samples, 73.73 sample hours
Irradiation of foils for counter experiments, including absolute counting for neutron flux measurements; activation of samples for neutron activation analysis experiment. Powr operation for a laboratory radiation survey to demonstrate use of radiation monitoring instruments. UW support

NEEP 428 (Nuclear Reactor Laboratory)
73 samples, 73.73 sample hours

Irradiation of foils for resonance integral measurement and fast neutron flux measurement. Operation for critical experiment, control element calibration, and pulsing parameter measurements. UW support

NWT/Commonwealth-Edison Braidwood Nuclear Power plant
2 samples, 11.4 sample hours
Activation of sodium to Na-24 for steam generator carryover tests. Industrial support

NWT /Commonwealth-Edison Byron Nuclear Power Plant
1 sample, 3.92 sample hours
Activation of sodium to Na-24 for steam generator carryover tests. Industrial support

Soil Science Department
123 Samples, 73.9 sample hours
Professor P. Helmke and 4 graduate students. NAA of soils and biological material and preparation of radioisotopes for study of element behavior in laboratory soil and water-plant systems. Support by United States Department of Agriculture and Hatch Act

Sumner Associates (NAA)
19 samples, 4.75 sample hours
Analysis of Indium content of air particulate samples on filter paper. Industrial support.

UOP (NAA)
23 samples, 4.1 sample hours
Determination of Chlorine in catalyst samples. Industrial support.

4. OTHER MAJOR RESEARCH USE

Development of the neutron radiography facility continued. A faster digital camera was procured and brought to operational status. The next step is to produce neutron radiographs using an image intensifier and the camera at a high framing rate to obtain stop-motion neutron radiographs.

5. CHANGES IN PERSONNEL, FACILITY AND PROCEDURES

Any changes reportable under 10 CFR 50.59 are indicated in section E of this report.

Additional upgrading of the facility, not reportable under 10CRF 50.59, was completed during the year.

Personnel changes during the year were as follows:

The following individuals were appointed as Reactor Operators upon licensing by NRC.

Amy Hagner
Douglass Henderson
Andy Smolinski
Elizabeth Young

Professor William F. Vogelsang resigned as chair of the Reactor Safety Committee to devote further time to his retirement interests. Professor Douglass Henderson was appointed to replace Professor Vogelsang as chair.

6. RESULTS OF SURVEILLANCE TESTS

The program of inspection and testing of reactor components continues. Inspection of underwater components in December 1998 showed no deterioration or wear except for a small hole in the clad of the transient control rod. This transient rod (boron-carbide poison section) had been in the core since February 1993 and showed no signs of corrosion or swelling. The hole was in a rubbing area, but micrometer measurements did not show a diameter reduction due to wear. The transient rod was replaced with a spare. We believe the clad defect in the removed transient rod can be repaired after the radiation level is allowed to decay away.

On May 13, 1999 the 1 kW pulse and square wave permissive relay chattered while power level was coasting down after a shutdown. This relay is operarated by a bistable within the LogN-Period channel. The instrument had calibrated properly and the period relay had actuated at the proper period during the pre-startup checkout, and the 1 kW permissive relay had actuated properly when it was checked during the pre-startup checklist. The instrument was removed to the electronic shop for troubleshooting. The negative 15 volt regulator (an IRC ua7915 three-terminal regulator) in the instrument power supply had failed to a low voltage. The regulator chip was replaced and the instrument was returned to service. The chatter was assumed to be due to the ripple in the power supply with the voltage regulator malfunctioning. This is the first failure of this component in the two Log N amplifiers which have been in operation since the instruments were built and installed in January 1981.

B. OPERATING STATISTICS AND FUEL EXPOSURE

Operating Period	Critical Hrs	MW Hrs	Runs	Pulses
fiscal year 1998-99	601.76	507.07	212	43
FLIP Core	13455.43	11160.89	3801	738
TRIGA	20720.42	16149.07	5791	2159

Core I23-R10 was operated throughout the year. The excess reactivity of this core increased 0.148%ρ to 4.192%ρ during the year. FLIP cores are expected to increase reactivity during the first 5 MW-years.

C. EMERGENCY SHUTDOWNS AND INADVERTENT SCRAMS

There were two automatic scrams or inadvertent shutdowns during the year. Each is described below in chronological sequence.

- October 30, 1998 Relay and electronic scram from picoammeter #2 during a re-start after a deliberate reactor scram in a reactor operation demonstration. Although the reactor was already shut down, the scram had been reset for a subsequent startup. The operator down-ranged the picoammeter too far, thus causing the scram.

February 15, 1999 Relay and electronic scram from picoammeter#2. Operator trainee in NEEP 234 course down-ranged the picoammeter one range too far.

Although not an emergency shutdown, the reactor was shut down during a run on August 18, 1998 because the console recorder stopped printing. The diagnostic given was "carriage drive motor failure", but the actual failure turned out to be binding of the carriage because the ribbon became tangled and prevented the carriage from moving.

D. MAINTENANCE

Routine preventive maintenance continued to maintain equipment operability. The secondary cooling system was chemically cleaned to remove scale from hard water deposits. The water softener was replaced after many years of service with a unit which is capable of continuous supply of soft water. This enabled changing all makeup and cooling water to the still to soft water, greatly extending the time between still cleaning. Makeup to the secondary cooling system was also changed to soft water.

E. CHANGES IN THE FACILITY OR PROCEDURES REPORTABLE UNDER 10CFR 50.59

There were no changes in the facility of procedures reportable under 10CFR Part 50.59.

F. RADIOACTIVE WASTE DISPOSAL

1. SOLID WASTE

No solid waste was transferred from the facility during the year.

2. LIQUID WASTE

Liquid waste discharges are detailed in Table 1.

3. PARTICULATE AND GASEOUS ACTIVITY RELEASED TO THE ATMOSPHERE

Table 2 presents information on stack discharges during the year.

G. SUMMARY OF RADIATION EXPOSURE OF PERSONNEL (Calendar year 1998)

No personnel received any significant radiation exposure for the above period. The highest doses recorded were 32 mrem to the whole body, 32 mrem to skin, and 156 mrem to extremities.

H. RESULTS OF ENVIRONMENTAL SURVEYS (Fiscal year 1998-99)

The environmental monitoring program at Wisconsin uses Eberline TLD area monitors located in areas surrounding the reactor laboratory. Table 3 indicates the dose a person would have received if continuously present in the indicated area for the full year.

I. PUBLICATIONS BASED ON REACTOR USE

"Correlative Instrumental Neutron Activation Analysis, Light Microscopy, Transmission Electron Microscopy, and X-ray Microanalysis for Qualitative and Quantitative Detection of Colloidal Gold Spheres in Biological Specimens", Julian F. Hillyer and Ralph M. Albrecht, Microscopy and Microanalysis 4, 481-490, 1999

Table 1 LIQUID RADIOACTIVE WASTE DISCHARGED TO SEWER

		8/1/96	6/6/97	Total
	Date	8/1/96	6/6/97	Total
	Total µCi	537.98	40.03	578.01
	Gallons	1200	1425	2625
Isotope / MPC				
Co-57				
6.00E-04	µCi	0.00E+00	0.00E+00	0.00E+00
	µCi/ml	0.00E+00	0.00E+00	0.00E+00
	Fraction of MPC	0.00E+00	0.00E+00	0.00E+00
Co-58	µCi	6.73	4.43	11.16
2.00E-04	µCi/ml	1.48E-06	8.21E-07	1.12E-06
	Fraction of MPC	7.41E-03	4.11E-03	5.62E-03
Co-60	µCi	7.33	5.30	12.63
3.00E-05	µCi/ml	1.61E-06	9.83E-07	1.27E-06
	Fraction of MPC	5.38E-02	3.28E-02	4.24E-02
Cr-51	µCi	40.55	0.00	40.55
5.00E-03	µCi/ml	8.93E-06	0.00E+00	4.08E-06
	Fraction of MPC	1.79E-03	0.00E+00	8.16E-04
K-40	µCi	347.55	3.51	351.06
4.00E-05	µCi/ml	7.65E-05	6.51E-07	3.53E-05
	Fraction of MPC	1.91E+00	1.63E-02	8.83E-01
Mn-54	µCi	12.78	11.40	24.18
3.00E-04	µCi/ml	2.81E-06	2.11E-06	2.43E-06
	Fraction of MPC	9.38E-03	7.05E-03	8.11E-03
Ru-106	µCi	43.67	14.94	58.61
3.00E-05	µCi/ml	9.61E-06	2.77E-06	5.90E-06
	Fraction of MPC	3.20E-01	9.23E-02	1.97E-01
Zn-65	µCi	79.37	0.45	79.82
5.00E-05	µCi/ml	1.75E-05	9.91E-08	8.03E-06
	Fraction of MPC	3.49E-01	1.98E-03	1.61E-01
TOTAL				
	No dilution Fraction of MPC	2.66	0.15	0.41
	Daily dilution Fraction of MPC	0.13	0.01	0.01

Average concentration (µCi/ml) at point of release to sewer =	5.82E-05
Avg. fraction of release limit w/o dilution =	0.41
Max. fraction of release limit w/o dilution =	2.66
Average daily sewage flow for dilution (gallons) =	2.37E+04
Max. fraction of MONTHLY release limit with DAILY dilution =	0.13
Max. fraction of MONTHLY release limit with MONTHLY dilution =	0.01

TABLE 2 EFFLUENT FROM STACK

1. Particulate Activity

   There was no discharge of particulate activity above background levels.

2. Gaseous Activity - All Argon-41

Month	Activity Discharged (Curies)	Maximum Concentration µCi/ml x 1E-6	Average Concentration µCi/ml x 1E-6
July 1996	0.03723	3.5	0.0208
August	0.05195	4.4	0.0290
September	0.14768	8.0	0.0851
October	0.05973	3.9	0.0333
November	0.07267	7.3	0.0419
December	0.05584	2.2	0.0311
January 1997	0.06923	2.8	0.0393
February	0.13765	2.4	0.0850
March	0.14087	2.4	0.0786
April	0.16438	3.1	0.0947
May	0.16794	3.2	0.0937
June	0.11690	3.2	0.0674
	Total	Maximum	Average
	1.22207	8	0.0583
The concentration resulting in 1E-8 personnel exposure is 8E-6 at stack discharge.			

TABLE 3 ANNUAL DOSE DATA -- Environmental Monitors

Location	Annual Dose mrem
Control- kept in lead shield except for shipment from and to processor	93.6
Inside Wall of Reactor Laboratory	237.4
Inside Reactor Laboratory Stack	150.2
Highest Dose Outside Reactor Laboratory (Reactor Lab roof ladder: monitor adjacent to stone surface)	155.4
Highest Dose in Occupied Nonrestricted Area (window of second floor classroom) Room 393	103.3
Average Dose in all Nonrestricted Areas (27 Monitor Points)	106.0